

**Marketing In Technology-Intensive Markets:
Toward A Conceptual Framework (forthcoming, Journal of Marketing, 2000)**

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MARKETING IN TECHNOLOGY-INTENSIVE MARKETS: TOWARDS A CONCEPTUAL FRAMEWORK

ABSTRACT

It is becoming clear that markets in which technology assumes a central role are becoming driving forces of the economy. We label these “technology-intensive” (TI) markets. Despite their importance, however, we lack a clear understanding of the features of a TI market. Extant work has not yet provided us insights into decisions that are unique and/or critical to this domain and how the features of these markets may influence these decisions. We offer a framework to address these gaps. Based on scientific know-how as the foundational concept, we explore the nuances of know-how creation, dissemination and utilization help us identify eight features of TI markets. We study four marketing decisions, beginning with the most fundamental one, viz. the vertical positioning decision (which is the firm’s decision of what it sells). Product design decisions (both platform and modularity) transfer rights decisions (which incorporates both price formats and licensing restrictions) and migration decision (whether and how to move customers through an on-going stream of technological innovations) round out the set. The linkages between TI market features and these marketing decisions are articulated by a series of refutable empirical propositions that combine to form a nomological network.

INTRODUCTION

Technology is at the core of diverse contemporary markets, ranging from common-place business and consumer products (e.g., fax machines and digital “pets”) to esoteric products with diverse yet fundamental applications (e.g., routers, extensible object-oriented databases, digital signal processors, and gene sequence analyzers). We call these “technology-intensive” (TI) markets. Such markets are significant in several respects.

First, technology is a powerful engine of economic progress. It has been estimated that TI markets added almost a full point to U.S. economic growth last year (Mandel, 1998). This is no transitory phenomenon, either. Technology has been the principal driver of the phenomenal increases in productivity and well-being of human societies achieved since the Industrial Revolution (e.g., Mokyr, 1990). Further, these trends are show no sign of abating. To the contrary, the effects and influence of technology are expected to accelerate (Quinn 1992). These markets themselves are growing at twice the growth rate of the economy according to government statistics (Dept. of Commerce, 1996).

However, consensus views of the business implications of these markets are lacking. Technology evangelists describe these markets as “ ... different as the moon is from the earth...” (Dyson, 1994). Even some accounts in the marketing literature accord a limited role for marketing in TI settings (e.g., Workman, 1993). On the other hand, skeptics contend that nothing is fundamentally different about such markets, and conventional marketing insights into branding, positioning, distribution, etc. can be usefully extrapolated to TI markets.

The extant research does not provide much help in resolving these competing views. We acknowledge that some work in marketing and allied fields has improved considerably our understanding of TI domains (e.g., Capon and Glazer 1987, von Hippel, 1986). Indeed, for specific topics like compatibility and network externalities, hundreds of analytical models have been developed by economists. However, empirical evidence is very scarce. Thus, robust explanations have not yet been sorted out. In short, our current understanding of TI markets is sparse, disparate, and without consensus.

These disagreements carry over into the public policy and antitrust arena. The argument is often made that the dynamic business aspects of technology-driven markets render conventional business and strategy analysis useless. Consider the contrasting view offered by a Deputy

Assistant Attorney General: "... rapid technological progress hardly implies that antitrust enforcers should sit on the sidelines ... our job is to ensure that incumbent firms do not use their power to block technological progress..." (Shapiro, 1996).

A conceptual lens to view TI markets would help to guide theoretical and empirical research by disclosing what is currently known, and highlight the gaps in our current understanding. It would help us apply our extant understanding of marketing processes to the TI domain, and would permit a more reasoned assessment of conflicting claims.

Toward this end, we draw together several issues that have been examined both directly and indirectly in prior research, and others that have been ignored. Immediately below, we lay the foundation of our framework (Figure 1) which features *scientific know-how* as the foundational element of TI markets. The following section traces the ramifications of *features* of these markets arising from know-how intensity. *Marketing decisions*, including *vertical positioning decisions*, (which represents the firm's decision of what a firm sells), *platform positioning* decisions, and *migration* decisions over overlapping generations of technological innovations are assessed in the next section by developing linkages to the features of these markets. A series of refutable empirical propositions are developed to articulate these linkages. We close the paper with a review of our substantive conclusions, including future research needs and the implications for managers who operate in TI markets.

KNOW-HOW AND TECHNOLOGY-INTENSIVE MARKETS

So many different lay meanings are already attached to the word "technology" that an attempt to generate an inclusive definition would only add to the confusion. Instead, we develop a working definition for the purpose of this paper by reference to the underlying characteristics¹. To this end, we begin with the term "technology". Like previous authors, we view it as *scientific knowledge applied to useful purposes* (e.g., Quinn et al. 1997; Capon and Glazer 1987). Also termed *know-how*, this captures the scientific knowledge embodied in a product's functionality as well as the knowledge required to manufacture and sell it. Products (and services)² are therefore manifestations of know-how. This eliminates the distinction between a product and the technology it encompasses—a distinction that is often difficult, if not impossible, to make (Glazer 1991).

Know-how transforms the business aspects of a market in profound ways; consider the business of dam-building. Dams have been built throughout the world for centuries by applying little-understood principles acquired through experience – an industrial art form. At the turn of this century, the science of soil mechanics was developed, which transformed the business. First, it enabled a much greater variety of dam designs to be considered and compared systematically. Second, the hitherto monolithic product built painstakingly through trial and error was now decomposable into sub-systems whereby independently occurring advances in steel reinforcement, concrete fabrication, watershed mapping processes, etc. could all be brought to bear to deliver an improved dam. This made it impractical for any one firm to be a specialist in all relevant matters. Consequently, heterogeneous firms with differential competencies emerged. Since these sub-systems have to function properly with each other in a coordinated fashion, standards and interfaces also became salient business issues.

Our view of scientific know-how as a foundational concept for TI markets is a discriminating one. Contrast it with complexity and speed as alternative foundational concepts.

Know-How vs Complexity We do not equate know-how intensity with complexity per se in design, manufacture or use. First, customers may use a very complex product without being influenced (or even aware) of the underlying complexity (e.g., digital pets). Second, and more importantly, many markets are both complex in design and production respects, and require considerable knowledge, but not of the scientific variety.

Rather, they involve craft skills and industrial artisanship which are different from scientific know-how in their generation and application. For instance, violins are complex in their design and manufacture, and require very skilled craftsmen. However, the relevant knowledge is not science-based, but an art form. Unlike scientific know-how, progress in industrial arts is very incremental, and even regressive on occasion. For instance, even today, we are unable to replicate the Stradivarius violins made by an half-blind, virtually illiterate Italian craftsman over a hundred years ago.

Complex industrial products are also typically commercialized well before scientific know-how plays a significant role. Airplanes, steamships, electric generators and pharmaceutical drugs were all commercial businesses long before their scientific bases were developed (Mokyr, 1990). However, the vastly increased design variety, decomposition into sub-systems and rapid

introduction of advances illustrated in our dam building example did not occur in these businesses until their scientific bases were developed more fully. In short, complexity is insufficient as a foundational concept.

Know-How vs Speed We do not equate know-how intensity with fast-paced change in demand and/or supply conditions. Clearly, rapid change occurs in TI markets, but many other markets exist where the change of pace is high, yet the business is not heavily informed by scientific know-how. Cultural industries like books, music and fashion all exhibit fast-paced change, as well as the use of intellectual property, but it is not scientific know-how. While we might learn lessons about short product cycles from these markets, speed as a foundational concept for TI markets casts too wide a net.

A Working Definition TI markets are characterized by products and services based significantly on scientific and technical know-how. Complexity and speed of change are corollaries of know-how intensity, not foundational concepts.

KNOW-HOW AND TI MARKET FEATURES

Since know-how is the foundational concept for TI markets, it is logical to characterize the relevant features of these markets by studying the nature of know-how itself. To this end, we focus on the manner in which know-how itself is created, disseminated, and utilized. As such, we isolate three aspects of know-how that are tied to specific features of TI markets.

Depth of Know-How

By definition, all TI markets employ know-how to some non-trivial extent. That said, it is intuitively obvious that its impact depends on its relative magnitude and importance compared to other assets in the same market. When know-how itself represent a substantial portion of the total investment requirements, and hence of the value of the product itself, there are high levels of research and development spending by firms. This is considered such an important indicant that the U.S. Commerce Department uses this metric to define “high-tech” industries—any industry with double the R&D expenditures to sales as compared to the average is placed in the high tech category (Shanklin and Ryans, 1984).

As R&D expenditures become an increasingly large fraction of all expenditures, the market itself mirrors know-how creation, dissemination and utilization. Know-how creation costs

are both fixed and sunk. Additional costs to create multiple units of know-how are not relevant. Similarly, dissemination and utilization of know-how does not use up the stock of know-how. To the contrary, utilization often improves or increases the stock. As we elaborate below, these aspects of know-how processes manifest themselves in two particular TI market features.

Unit One Costs Markets dominated by investments in know-how feature high “unit one” cost structures. The cost of *producing* the first unit is very high relative to the costs of *reproduction*. To illustrate, the cost of pressing and distributing a CD-ROM are trivial compared to the cost of hiring programmers and content specialists to develop the software code recorded on it. Digital distribution reduces further the reproduction cost (essentially to zero) since customers can and do create (download) their own copies.

While these fixed development costs appear similar to the fixed costs of investments in physical assets found in many other industries, there are profound differences. For instance, an electric utility has a very high fixed plant cost, but this only represents an investment in capacity that is used up over time. In contrast, know-how is never used up, and is infinitely extensible. Thus, it is not a capacity investment like fixed physical assets. Instead, we have supply-side increasing returns to scale in the extreme. This magnifies the classic natural monopoly problem. It is inevitable that one dominant firm emerges, but given the rapid pace of change in these markets, a once-dominant firm may be supplanted by another firm. A useful metaphor for competition is that of a series of races, each one won by some firm.

We note that the dominance of unit one costs is relevant for tangible as well as intangible TI markets. Medical devices and microprocessor firms do not face zero reproduction costs, yet their material and labor cost of production and distribution are an order of magnitude smaller than the know-how development costs. As we shall elaborate later, a cost structure dominated by unit one costs profoundly influences a firm’s positioning and pricing decisions, often in counter-intuitive ways.

Tradability Problems When know-how represents a substantial portion of the value of the products and services in question, exchanges are effectively transformed into intellectual property transactions, albeit wrapped within a tangible product transaction. Thus, TI markets mirror the complications of completing economic transactions directly for know-how (e.g., Teece, 1988).

Pre-transfer problems include the fact that a buyer can value intellectual property best after they have acquired it. Of course, sellers are loath to permit buyers to “try it out” since knowledge once acquired cannot be returned or “forgotten”. Another problem is that the use or possession by one licensee/buyer does not diminish its subsequent availability to another buyer. The original seller can sell unlimited “copies” later at nearly zero reproduction cost. Promises not to sell elsewhere or at lower prices are not credible per se. This makes it more difficult for the first buyer to assess the potential value of the property especially if they might be in subsequent competition with firms buying later from the same supplier. In turn, this makes it more difficult to arrive at a mutually satisfactory deal.

Post-transfer problems also abound. For instance, a buyer may “sit” on a technology to protect its own (obsolete) technology. Such disabilities are exacerbated in international markets because of more fragile property rights. While trade involving a tangible product, or even an intangible like a brand name always accommodates termination as a effective safeguard against adverse outcomes, termination per se is not credible with technology transactions because the buyer retains the relevant knowledge even after termination.

Such problems are magnified when the know-how in question is increasingly *tacit* in nature. Tacit know-how is defined as know-how that is difficult to convey via documentation (Polanyi 1958) and thus not readily verifiable by third parties. Examples include process know-how and experience-based human skills. In contrast, codifiable know-how is amenable to the printed page and can be easily transmitted in patent specifications and the like. Since intellectual property rights rest on third party verification to enforce patents and licenses, the post transfer problems discussed above are magnified with tacit know-how.

In sum, tradability problems characterize TI markets, especially when tacit know-how is prominent. As we shall elaborate later, these tradability problems have a profound influence on a firm’s positioning and compatibility decisions.

Externalities in Know-How

Externalities are defined as spillovers. In our context, positive spillovers exist in know-how creation, dissemination and usage. Thus, the productivity of know-how creation is enhanced when new stock of know-how further enriches an already existing stock of know-how. Similarly, productivity of know-how dissemination and utilization is enhanced when both the source and

target can build on the stock of know-how which the other possesses. Empirical work has documented these positive externalities in know-how creation, dissemination and utilization within industries, across industries and between academia and industry (e.g., Jaffe, 1986; 1989).

These externalities create increasing returns in know-how creation and distribution which make them markedly different from “normal” production and distribution processes that feature familiar diminishing returns properties. TI markets mirror these distinctions in three respects.

Diversity of Technologies Iansiti and West (1997) observe that inter-disciplinary work and integration of technologies are very common in TI markets. For instance, implantable medical devices depend on micro-electronics, non-reactive materials technology, and battery technology. Often, these know-how bases are spread widely across firms and industries and users. Indeed, as von Hippel (1986) documents, so-called “lead users” have often been responsible for a lion’s share of the commercialized innovations in TI markets. These are unsurprising facts if we consider the implication of externalities. Since spillovers spur advances at multiple places within groups of interacting firms and users, it is all but inevitable that the breadth of know-how employed grows over time.

It is not just the diversity of know-how that grows, but the manner in which new know-how is introduced. Historical accounts tell us that as know-how intensity increases in a market, monolithic products become transformed into decomposable systems. This is a fundamentally significant transformation.

For instance, rifles were crafted individually until the Civil War when machining technology made interchangeable components possible. In turn, improvements in one component could be introduced independent of the others. Not only is there greater unbundling over time in TI markets as per Wilson, Weiss, and John (1990), which encourages new technology to be introduced into *mixed-and-matched* systems to better fit customers’ ideal points, but “enabling technologies” accelerate the diversity of technologies even further.

Enabling technologies typically come from outside the immediate domain of a particular application, but ultimately are incorporated to enhance the benefits of the products involved. For example, computing information was historically delivered over localized systems such as mainframe or desktop computers. The development of high-speed Internet links, high-capacity local storage, flat-panel displays and alternative input devices represent enabling technologies for

wide-area mobile access to this information. Systems become even more diverse as enabling technologies are incorporated.

In sum, as the diversity of technologies increase, products are transformed into systems that offer marketers dizzying possibilities for unpacking them into sub-systems and components. Several marketing decisions are directly influenced, including modularity in product design, and the components vs systems decision.

Network Compatibility Externalities in know-how creation and dissemination create networks whereby collections of users, and/or producers coalesce around sets of complementary know-how (Farrell and Saloner, 1986). Both physical networks like a phone system, and logical networks like the “Wintel” network comprised of Microsoft operating systems and Intel processors are created.

There are large gains from compatible networks. Positive spillovers in know-creation accelerate the rate of progress when a community of users or producers coalesce around common standards. In addition, the larger market size itself creates lower costs from increased scale and competition. These common standards or *compatibility* regimes vary across TI market networks.

Compatibility consists of the standards and rules that allow sub-systems of products to work together without special modification. Compatibility is not an all or nothing proposition, but rather a matter of degree. For example, in computer inter-networking, protocols such as TCP/IP allow high intra-system compatibility. At the same time, other areas within the same system (e.g., real-time video streaming) exhibit low compatibility because of differences in implementations of a common denominator protocol.

There are qualitative differences in the types of compatibility regimes observed. In some TI markets, compatibility derives from a dominant sponsor who achieves “proprietary control” (Morris and Ferguson, 1993) while a collective or “open control” regime dominates in other instances. An example of the former would be the various interfaces promulgated and controlled by IBM in the mainframe market. In the case of social control, (also called open standards) some collective body controls the interfaces. An example is the TCP/IP standards in the networking market. Although there is a large analytical literature on network compatibility, there is scant empirical evidence on these matters as Brynjolfsson and Kemerer (1995) observe in their study estimating network externality effects in the spreadsheet market. As we discuss later, marketing

decisions about product design modularity are directly influenced by the compatibility regimes in a TI market.

Demand-side Increasing Returns. Externalities in know-how creation and dissemination also create demand-side increasing returns in TI markets. Also called a bandwagon effect, it refers to the situation where the utility of the item to the $n+1^{\text{th}}$ adopter is a function of previous n adopters. The classic example is the telephone, where the more people who adopt the telephone, the higher the benefits to each adopter. The increasing returns are often located in complementary products or peripherals, such as software for computers or pre-recorded cassettes for videotape machines. Observe that the bandwagon effect is magnified by greater compatibility within a network of complementary items.

Demand-side increasing returns create fierce winner-take-all battles between competing systems in TI markets. Furthermore, “objectively” superior technology embodied in a firm’s product does not dictate success. Market tipping from small historical events can lead to lock-in with a (possibly) inferior technology. The QWERTY keyboard (Arthur, 1994) and the Beta-VHS tape format are often cited as the canonical examples.

These increasing returns arguments are at the heart of the public policy dilemma in the Microsoft antitrust case. As noted, single-firm dominance of increasing returns markets are almost inevitable. Microsoft’s dominance of the Windows marketplace can be justified by appealing to the consumer benefits of the Wintel network that was created as a consequence. The dilemma is that its dominance might also have the effect of locking out potential competitors into the future. It is particularly difficult to assess conduct like exclusivity contracts and mergers or buyouts by dominant firms which plausibly grow the incumbent network but also make it difficult for competitors to enter and challenge with new, competing products.

We note the controversy about the empirical significance of these phenomena. Liebowitz and Margolis (1995) examined the history of Beta vs VHS tape format battle, and found no evidence of demand-side increasing returns. Unfortunately, systematic empirical evidence that could be of great help is sorely lacking. These controversies notwithstanding, demand-side increasing returns have obvious implications for various marketing decisions. Most notably, a firm’s pricing decisions may be tailored to take advantage of increasing returns. We elaborate on this issue later.

Evolution of Know-How

Unlike physical assets, know-how is “self-regenerative” and evolves, in that one piece of know-how creates the conditions for subsequent pieces (Glazer 1991). Furthermore, the pace of know-how creation can *accelerate* as individuals and firms become increasingly skilled at exploiting a set of ideas (Romer 1990). It is also path-dependent as a consequence. These positive feedback processes make the trajectory of know-how quite volatile, and highly susceptible to small changes. Altogether, these influences make participants uncertain about the timing and trajectory of progress, although it is inevitable that progress will occur.

Although improved products are always welcome in any marketplace, they are particularly important in TI markets. Know-how intensive products (e.g., a word processor) are virtually infinitely durable, so repeat purchases are driven primarily by improvements. Thus, expectations of improvements play a crucial role here. Three different aspects of expectations are implicated.

Expectations of Pace of Improvements The evolutionary aspects of know-how creation described above virtually guarantee that TI markets feature an on-going stream of improved and over-lapping product generations. Dynamic random access memory chips and microprocessors are two of the most familiar examples of constantly improved generations. An obvious consequence is that the improved versions obsolete older ones while they are still perfectly functional in use. Customers, recognizing this, begin to form expectations of further and continuing advances (Rosenberg 1976) in performance and decrements in price. They must balance the value (and potential obsolescence) of *installed* product generations against the potential value of *current* offerings and *future* arrivals in making upgrade decisions. The marketer’s task of managing transitions between generations is obviously impacted by these conflicting influences.

It is important to note that these constant upgrades are not confined to contemporary computer markets. Industrial machinery often exhibits this rapid pace of revisions. To cite a historical example, Kaysen (1956) documented that United Shoe Machinery introduced, on average, about 200 changes over the life of an individual model of shoe machine. Their customers clearly anticipated constant revisions in the state-of-the-art.

Expectations of Significance of Improvements Pace aside, the magnitude or size of improvements in TI markets can vary quite dramatically. On the one hand, fast but incremental (evolutionary) change results in new generations that are mostly updated versions of earlier ones. In contrast, fast and significant (revolutionary) improvements result in “inflection points” or technological discontinuities. Truly significant improvements can be “competence-destroying” as well. For example, the commercial airplane industry is currently moving from 50 years of hydraulic controls to utilizing “fly-by-wire” controls, which is a competence-destroying advance for the hydraulics specialists.

Customers’ beliefs about the significance/size of anticipated improvements have effects quite distinct from pace per se. While significant improvements obviously prompt purchases once they arrive, they can have a chilling effect when they are expected imminently. Thus, tailoring marketing decisions about migration in the light of large expected improvements is a crucial element of TI markets.

Uncertainty of Expectations. Expectations are obviously not held with certainty. Strongly held expectations result from consistent progress like microprocessor capabilities, while expectations during inflection points are much more uncertain. For instance, new techniques (such as “xerogel” bubbles or advances in etching techniques) may increase microprocessor growth rates substantially, but these are presently only industry conjectures and it is difficult to predict their impact. In other instances, uncertainty may be related to complementary technologies, such as the future capabilities of operating systems and its effects on applications software capability. An interesting example is the computer memory market, where the evolution of memory device design is far more certain than the improvements in test equipment necessary to fabricate these designs. In industry parlance borrowed from bicycle racing, the chip firms are said to “draft” test equipment firms.

Customer decisions in TI markets are strongly influenced by the uncertainty of their expectations as they migrate through a series of technological advances. As we elaborate later, marketing decisions to support these migration patterns are obviously affected by these uncertainties.

Summary of TI Market Features

We have shown that the fundamental character of scientific know-how create eight features of TI markets. Unit one cost structures, intellectual property tradability problems, highly diverse technologies, network compatibility issues, demand-side increasing returns, and customers' expectations about the pace, size and uncertainty of improvements are all salient in TI markets; however, the importance of a given feature depends on the specific market. Below, we highlight a series of important, and often unique, marketing decisions we argue are influenced by these market features.

MARKETING DECISION IN TI MARKETS

We begin with the most fundamental decision in a TI market. viz. what to sell. We label this vertical positioning decision. We then discuss two product design decisions, which pose unique new challenges in these markets. Choosing a platform design versus a conventional targeted product design is the first design issue considered. The second design issue is whether to use a modular system design or remain with the traditional optimized product design. The third major decision is the design of transfer rights, which can range from complete transfer of ownership to very limited per use rights. Migration assistance decision to move customers from one product generation to another rounds out the set.

We chose to focus on these four decisions because they are broadly representative of the types of decisions managers make in an environment where the foregoing TI features tend to operate, and conventional wisdom from marketing often does not carry over. They also represent live research opportunities as empirical work on these matters is very scarce.

In presenting these decisions, we note two important caveats. We identify two important caveats. First, commercializing technological know-how involves a range of assets from a broad base of technological competence and firms that do not have the necessary competencies or resources may acquire them through many different forms of alliances and partnerships. Our framework does not address how the firm's resources and capabilities enable or detract firms from making these decisions, nor do we address the manner by which firms obtain these resources. Stated differently, we are not addressing the question of the nature of the firm's resources or how a firm should be appropriately organized in these decisions (e.g., markets,

hierarchies, alliances, etc.). Instead, our focus is on the influence of the various features of know-how intensive markets on these critical marketing decisions.

Second, we make no claim that these decisions are linear, sequential decision processes. Indeed, marketing decisions in most markets are simultaneous processes subject to various interactions. Also, we make no claim that all the identified features of TI markets impact each and every decision. Instead, we will be focusing only on those features that we can logically relate to each decision. Our discussion is an initial attempt to represent in a parsimonious way the complexity of marketing in these settings. We stress that our discussion of the relationship between the market features and marketing decisions combine disparate research studies that have not been combined till now.

The Vertical Positioning Decision

All products in a TI market start with some valuable know-how. The firm owning the know-how must fashion a selling strategy for converting this know-how into revenues. We call this fundamentally important issue the “vertical positioning decision”.

A Continuum of Locations We depict the possible alternative locations along the continuum in Figure 2, which orders them by the funds expended by the buyer above and beyond the acquisition cost. These funds are expended on complementary products, services and training so that the intended benefits of the purchase can be realized. At the top (high) end of the continuum, firms sell know-how directly. For instance, chemical firms often sell (or license) the rights to a specific molecule to downstream producers. This vertical position is the furthest from final use, in that the item sold requires the greatest additional expenditures of funds by the target after the focal transaction to realize the final intended benefit.

One step removed from selling know-how directly is the sale of a “proof-of-concept”. Here, a prototype or pilot plant is developed to establish that the know-how can indeed be made to work. Further down the continuum are sales of commercial-grade components to OEMs. Even further down are sales of final products or systems that contain all the essential components so that it is ready for service “out-of the-box”. Finally, at the bottom end of the continuum, firms operate service bureaus that deliver the intended benefits directly with no additional expenditures required on complementary items.

To illustrate these possibilities, consider the desktop laser engine technology developed by Canon in the early 80s. It could have sold (or licensed) the know-how directly. It could have sold components (bare laser engines) to laser printer manufacturers. It could have sold print subsystems (the laser engine combined with the required low-level software) to printer systems firms like QMS or HP. It could have sold a complete system (the laser engine combined with low-level software and a higher-level “page description language” such as Postscript or PCL) that worked right out of the box to end-users. Finally, it could have established print service bureaus utilizing its equipment. In point of fact, it chose the print-subsystem location.

Historically the most common vertical positions have been quite close to the final use level. We infer this from aggregate royalty revenues that historically have only been a negligible sum compared to product revenues (much less than 1%) in TI markets. In fact, royalty revenues in these markets have been smaller than R&D expenditures (Thurow 1997).

However this picture is changing rapidly. Increasingly, firms are trying to realize revenues from know-how via different vertical positions. For instance, Texas Instruments, which previously relied on selling components and final products, has in some recent years received more in licensing fees than its entire operating income (Thurow 1997). Multiple vertical locations are also a growing phenomenon. Returning to the laser printer market, Canon simultaneously sold printer subsystems to QMS, HP and Apple, as well as a ready-to-use laser printer (the LBP4) to end customers. More recently, IBM has become an aggressive vendor of components like disk drives and chips in addition to systems.

Vertical Positioning is not Vertical Integration Vertical positioning is a more fundamental decision than vertical integration. The make or buy decision is predicated on what is to be sold. After deciding what to sell, a firm can then decide whether to manufacture or source it.

HP’s decision in the laser printer market can be contrasted with its choice in the inkjet printer market to illustrate this point. They sold complete systems in both cases. However, their vertical integration strategy was drastically different. HP purchased laser print subsystems from Canon, but manufactured their own inkjet print subsystems.

Vertical Positioning is not Value Chain Position As per Porter, define a firm’s position in a value chain as its set of activities within the overall set of activities undertaken by all the relevant firms. In contrast, its vertical position is not defined over activity sets. Rather, it is

defined over the stock of relevant know-how that it owns or controls, and the manner in which it chooses to transform this know-how into revenues. To illustrate the difference, suppose that A manufactured a complete printer for B using B's know-how and design. A adds its manufacturing process know-how to the mix. A's vertical position is not at the finished product level, although it manufactures the complete product. Rather, A's vertical position is at the know-how level since they have elected to sell this (manufacturing process know-how) directly .

Attractiveness of Different Vertical Positions Although know-how intensity leads to decomposition of monolithic products into sub-systems and components, which creates alternative vertical positions, it is not the case that all these positions are equally attractive. Farrell, Monroe and Saloner (1998) develop analytic models to show that competing at one level (say components) is different from competing at another level (say systems) in the same product category. Both strategic interactions and profitability consequences are different.

Typically, we observe that most of the profits are captured by firms located at one or two favored locations, and these locations shift over time. For instance, in the personal computer industry, most of the profits flow to firms that compete at the component and subsystems levels. Intel sells microprocessors as components and motherboards as sub-systems, while Microsoft sells its operating systems and applications as sub-systems and components respectively. In contrast, in the mainframe computer industry, most of the profits flow to firms like IBM, NEC, etc. that compete at the systems level. A number of factors are responsible for different vertical positions being favored across markets.

Diversity Effects Highly diverse technologies in a TI market make it increasingly unlikely that a single firm can maintain its lead on all the relevant technologies across all the components or subsystems of the final product. Put differently, firms locating at lower levels find themselves handicapped on cost and/or quality dimensions in their efforts to keep up. In contrast, locating at higher vertical positions enables them to specialize and hence deliver lower costs or higher quality components or subsystems. This logic leads to the following testable proposition:

P1: Greater diversity of technologies in a TI market make higher vertical positions more attractive.

Since all TI markets are characterized by some diversity of technologies in final products, and such diversity tends to increase over time, there is a powerful trend towards

componentization. However, what might offset the pull towards locating further away from final use?

Compatibility Effects “Mix and matching” compatible components appeals to customers because it makes it easier for them to find a system suited to their own idiosyncratic needs (closer to their ideal-point in product-map terminology). It also appeals to producers as it allows them to specialize on a narrower range of relevant technologies, especially when these technologies are very diverse.

In contrast, poor compatibility regimes raise the cost of putting together an acceptable system, or even render it infeasible. Selling know-how or individual components is difficult at best. A current example is the high-capacity (120MB) floppy disk from Imation. Since Imation does not produce drives itself, and existing drives are incompatible with the new disk, it has to persuade drive manufacturers to produce and market compatible high capacity drives. In contrast, Iomega faces an easier task for its ZIP product as it controls both the drive and the disks. Accordingly, we propose:

P2: Poorer compatibility regimes in TI markets make lower vertical positions more attractive.

Demand-side increasing returns effects Lower vertical positions are also handicapped when there are bandwagon effects from network externalities. The consequences of locating at a “wrong” vertical position can be vividly seen in the difficulties faced by Apple Computer which is located at a low vertical position (system level). Its emphasis on its proprietary hardware standards over “de facto” open standards built around the IBM PC platform made for a winner-take all battle for the attention of third party hardware and software developers. Specialist suppliers with state-of-the-art know-how are increasingly deserting Apple for the Wintel network. In turn, this weakens the Apple product itself as the firm falls further and further behind in keeping all of its subsystems up to date.

P3: Greater bandwagon effects in TI markets make higher vertical positions more attractive.

Tradability Effects Perhaps the biggest deterrent against locating at high vertical positions is that the know-how might not be tradable. Recall that intellectual property transactions involving tacit know-how were fraught with difficulties. In terms of the vertical position

decision, this virtually rules out the top of the continuum. On the other hand, if the firm is located lower in the continuum and tacit know-how is wrapped into a component or sub-system or even an entire system, the target is indifferent to the tacitness, and only needs to assess the benefits of the product embodying the know-how itself. Accordingly, we propose:

P4: Greater tacit know-how in TI markets make lower vertical positions more attractive.

It is worth noting that tradability is not a fixed characteristic of the stock of know-how. For instance, high band-width information technologies, including “live” computerized documentation, expert systems and multimedia (to simulate direct interaction) can all enhance tradability to the point that an intellectual property transaction becomes feasible. Alternatively, these firms can accept the extant tacitness, but target buyers who face smaller transfer problems.

The most compelling target for a intellectual property transaction involving tacit know-how is a customer that already possesses virtually the same know-how and/or is capable of producing it in short order. This is quite counter-intuitive, and an illustration will serve to fix the idea.

Consider process engineering and management consulting firms. Plainly, these firms are located at high levels of the vertical positioning continuum, but the know-how being sold is also very tacit. How do they overcome the difficulties alluded to earlier? Briefly, they employ a targeting strategy quite different from the conventional dictum that customers with the highest value-in-use (reservation price) are the most attractive targets.

Contrast two prospective buyers; a sophisticated buyer with a large engineering (or management) staff in-house skilled in using the tools and methods employed by the outside consultant, versus a second buyer that lacks such resources. Conversations with consultants confirm that their best targets are sophisticated firms who could actually do the job with in-house resources. Why?

The absorptive capacity of the unsophisticated firm is lower in spite of their “greater need” (and presumably greater value-in-use) for the service in question. Thus, the sale is more difficult to close. Similar unusual effects are found in the utilization of publicly funded research by private industry. The intention of the public funding is to assist firms who have inadequate in-house research resources. However, firms with large research budgets, and staff are the most intensive users of academic and public-sector research. Thus, publicly funded work intended to

help resource-constrained firms actually increases the divergence between firms. Accordingly, we propose:

P5: Firms selling tacit know-how in TI markets find buyers more attractive when they already possess similar know-how.

Product Design Decisions

Regardless of the vertical position(s) chosen by a firm, it must decide on the most appropriate design for the product. Product design in contemporary marketing is exemplified by the quality function deployment (QFD) approach. QFD exhorts designers to listen to the voice of the customer by collecting information on customers' needs and preferences. After segmentation, each segment's needs are transformed into product design specifications intended to deliver the identified needs. The designer's task is to balance costs with quality/performance demanded by customers. The desired outcome is an optimized design that hits the segment's sweet spot or center of gravity.

The QFD approach to customer-driven product design faces two unique challenges in TI markets. First, should one design targeted products to hit a segment's sweet spot or should one design a common core, but with different versions for different segments (a "platform strategy")? Even more dramatic, should one optimize design given costs and customer needs of the target as per the QFD approach or should one deliberately *modularize* the design?

Target Platform or Target Product Decision? A platform product strategy entails offering several variants to different segments all based on a single core design. In contrast, with targeted products, one begins with each identified segment, and builds a product for it. TI markets dominated by unit one costs make the platform strategy more attractive. The idea is that if incremental costs of variants are relatively small compared to the core design, then it pays to proliferate versions of a common design to reach different willingness-to-pay segments since this adds incremental revenues (Varian, 1997). In contrast, trying to reach each small segment with tailored products is very expensive with unit one cost structures.

It is crucial that one designs the "right" core platform that can then be "versioned" relatively cheaply. In this regard, the QFD approach of specifying designs that most appeal to a segment is not very useful. Instead, the platform (called the reference design)³ version should be

designed for the high end of the user market, and should incorporate as many of the desired features as needed for this segment. This is counter-intuitive since the high end is unlikely to be representative of the general user. Nevertheless, large fixed development costs are more likely to be recovered from developing a design with the attribute levels desired by the highest willingness-to-pay segment. Then, lower priced versions can be sold at much lower prices given modest incremental cost. It is the asymmetry that makes this decision unique. Subtraction of features is a low incremental cost activity given existing stocks of know-how, but addition of features is most certainly not a low cost activity

A practical way to implement this is to use lead users as the principal “voice” of the customer (von Hippel 1986). A firm in the surgical dressing business used military combat hospitals as their principal source of customer input, even though the bulk of their sales were ultimately made through civilian hospitals. We reiterate that representativeness is not an issue, so traditional sampling notions are irrelevant. Likewise, concerns that lead-users might not foreshadow mass market needs are also irrelevant, since the platform design can be versioned down quite easily. Instead, it is critical to capture the high-end requirements adequately.

P6: TI markets dominated by unit one cost structures make platform designs more appropriate than segment-specific designs.

There are some curious consequences of a platform design. Since mass-market versions are created by stripping away features from the high-end version, and the product is not tailored to deliver the combination of features that the middle market desires, it is inevitable that they will be less satisfied than high-end customers. We speculate that customer satisfaction will be lower with this approach.

Modular or Optimized Designs?

Recall that know-how transformed monolithic products into systems. We distinguish two design strategies. Traditional engineering design employs constrained optimization methods to “... to obtain the highest level of product performance within a cost constraint” (Sanchez and Mahoney, 1996) This approach leads to systems “... composed of highly integrated, tightly coupled components”. In contrast, modular systems are designed with a view to isolating components from each other. “Standardized component interfaces that define functional, spatial and other relationships” are “... not permitted to change during an intended period”. They cite

many examples of modular designs, including the Boeing 777 aircraft, and Chrysler's LH platform. When is each design approach more appropriate?

Diversity Effects A high diversity of technologies enhances the likelihood that improvements will emerge in places outside the focal firm's reach or control. This requires the firm to maintain a flexible position. Adaptability would be compromised were it to decide to utilize an optimized design approach. Why?

With optimized designs, the tightly coupled components result in large numbers of changes that ripple through the system when one change is made. Contrast the use of "functional specifications" with the use of "design specifications". If one specifies that a commercial door's fireproofing requirements are to be accomplished by using 2 inches of fiberglass filling and a certain type of glue, etc. (a design specification) this is considerably less flexible than specifying that the door should resist a 500 degree flame for 15 minutes (a functional specification). In the latter case, an improvement in the know-how of gluing the parts of a door together can be "dropped-in" much more easily. The automobile industry is another example of a shift towards functional specifications. Component suppliers are able to take on more of the know-how development work. Accordingly, we posit:

P7: Greater diversity of technologies in TI markets make modular designs more attractive.

Tradability Effects As discussed earlier, when tradability problems are high, firms are faced with increased difficulty in transferring all the relevant know-how to other parties. Modular designs presuppose that the all the nuances of the know-how can be captured and transferred via published interfaces so that development work can proceed in parallel. To the extent that tacitness precludes this, modular designs are less useful. Accordingly,

P8: Greater tacitness in TI markets make modular designs less attractive.

Uncertainty Effects With more uncertainty about the evolution of technology, it pays to maintain flexibility because advances in one part of a system can be accommodated without scrapping the entire system. Modularized designs are much more capable in this regard. In effect, customers attach "option" value to such designs because it permits them to switch components at a later point if needed. As Grenadier and Weiss (1977) show, the value attached to options increase with uncertainty. Accordingly, we posit:

P9: Greater uncertainty about the evolution of technology in TI markets makes modular designs more attractive.

Transfer Rights Management

Intuit's CEO, Scott Cook, remarked that "... a hundred years ago, musicians, playwrights, athletes and actors died poor. Now, they die rich" (Bollier, 1998). He attributes the change to the development of new technologies for distribution and/or sale of know-how intensive products. Simply put, many more people can see a movie or read a book when reproduction and distribution costs shrink. These new distribution technologies also multiply the ways in which the revenues from intellectual property can be generated.

A Continuum of Transfer Rights Distribution and/or selling options for know-intensive products can be organized along the transfer rights continuum depicted in Figure 3. At one end, there is a complete transfer of rights where the buyer owns the product and can do whatever they please. At the other end are licensing arrangements that are highly restrictive in terms of volume, timing and purpose of usage. An example would be a micro-payment scheme as is envisioned for Java applets. A user would download an applet as and when needed, and it would self-destruct after the paid-for usage expired.

A naive view of transfer rights might assume that a seller should always maximize their rights, and transfer as few rights as possible. In this view, micropayment licensing schemes, if feasible, are always better than outright sales. However, this is myopic since buyers are willing to pay more for greater rights transferred to them. Thus, the point is not to minimize transfer rights per se, but to maximize profits by choosing "right" amount of rights to transfer. How is this accomplished? We examine three common transfer rights formats in TI markets; viz. outright sale vs. license, usage restrictions, and per use vs subscription pricing.

Outright Sales vs License

Uncertainty Effects In a world of certainty, transfer rights decisions are of little significance. The value of the product is known to both parties, and no greater efficiency attaches to any particular configuration of transfer rights. Uncertainty changes the game for buyer and seller. Uncertainty makes it more difficult to assess the value of the applications of the technology at the time of transfer. Thus, outright sales are more difficult to conclude since the net present value over the horizon has to be estimated. In contrast, short-term licenses over specific

fields of use can be estimated more readily. Subsequent fields of use can be estimated later as uncertainties resolve themselves. Of course, this reduces the revenue stream from the current transfer, but this trade-off becomes worthwhile with greater levels of uncertainty.

P14: Greater uncertainties about the evolution of the technology make outright sales less attractive than licensing

Individual use or Subsequent Use?

A large number of specific licensing formats can be usefully organized into a) those which restricts the target's rights to transfer the product to subsequent uses or users versus b) those licensing formats where such transfers are permitted. For instance, computer language compiler program licenses often require that a subsequent user of programs produced by a direct customer of that compiler product must pay royalties to the compiler firm. In contrast, a subsequent use license permits the original customer to produce programs with the compiler and sell it without further payments. Divx (Digital Video Express) and DVD (Digital Versatile Disk) technologies embody this distinction as well. While the inherent capabilities of these competing second generation CD-like devices are remarkably similar, Divx is a single play enabled format, while DVD is not restricted to a single viewing of its content. This choice is influenced by the dominance of unit one costs, tradability problems and uncertainty in the evolution of technologies.

Unit One Cost Effects Recall that unit cost structures created large fixed costs of producing the first product compared to the low costs for reproducing subsequent units. When customers can also reproduce copies at low cost, producers face two broad options. Charge a high price to a smaller number of intermediate customers (like video stores), but permit them to re-lease their product to their end-customers, or equivalently allow sharing among multiple users (like site licenses). Alternatively, charge a lower price to individual end-users, but not to permit sharing or re-transfers. Varian (1997) argues the choice turns on the ease with which customers can take on the task of distribution and/or sharing. When these costs are low, the firm is better off using the high-price, sharing option. The idea is that the lower cost of self-production increase customer valuation, so a higher price offsets the lower unit sales.

Operationally, this means selling to groups either directly or indirectly. For instance, networking has dropped the costs of "sharing" software dramatically in recent years, especially in

business locations. Thus, site licenses with rights-to-copy become more attractive than individual shrink-wrap licenses. Another example is the case of a medical device like the MRI. If there are large hospitals who have a higher willingness to pay but at the same time there exist a number of smaller hospitals which do not use the device as intensively and hence have a lower willingness to pay, then the MRI manufacturing firm can enhance its market by thinking of creative ways in which the smaller hospitals could share the product through some form of leasing arrangement. One way to accomplish this is to market a mobile version of the MRI product that is literally moved from site to site on a truck trailer. At the same time they can sell a fixed-site version directly to the larger hospitals. In sum, we posit:

P10: Greater unit costs dominance in TI markets favor subsequent use formats over individual use formats.

Tradability Effects When firms sell TI products with tradability problems, customers face inherent difficulties in re-transferring or sharing the product even if they desired to do so. Consequently, even if the firm permitted re-transfers, little additional value is attached to this right.

For instance, suppose an engineering firm licensed a customer the right to use a catalyst in a chemical process. The effectiveness of a catalyst often depends on tweaking the chemical reaction process which is a tacit skill. If the target possessed a “site license” for the catalyst for all its plants, it would nevertheless require the assistance of the source to tweak it successfully in each case. Thus, the source is better off designing single-plant licenses, and possibly even field-of-use restrictions. Otherwise, they are likely to face uncertain levels of costly technical support calls. The idea is that valuation (and hence exchange) is facilitated by defining its scope of use. Thus, we posit:

P11: Greater tradability problems in TI markets favor individual use formats over subsequent use formats.

Per Use or Subscription Prices?

Usage based pricing is a very common way to segment customers in TI markets. Conventional economics models hold that price discrimination, if feasible, is always more preferable. However, this is not true in TI markets.

Increasing Returns Effects When the value of a product to a prospective customer is increased by a larger number of other users, there is a premium on gaining an early lead over competing products since markets can “tip” in one’s favor. Encouraging usage by existing customers is one way to leverage these externalities. The experiences of numerous field trials of usage based pricing in the telephone industry (Fishburn, Odlyzko, and Siders, 1997) show that subscription pricing plans lead to increased usage. Conversely, per use pricing deters experimentation with unfamiliar products, and thus inhibits the growth of the network.

P12: Greater increasing returns effects in TI markets favor subscription pricing over per use pricing.

Interestingly, recent technological advances allow firms to tailor ever finer micro-payment schemes. For instance, digital watermarks permit passive monitoring of the number of times an image has been viewed. Likewise, the “network” computer promoted by Oracle and others is supposed to feature consumers downloading applications as needed, and paying for them on a per use basis. We suggest that firms which face increasing returns to scale in their market need to grow the network, and thus may be better off eschewing the pay per usage format even if their technology enables them to do so.

Uncertainty Effects. Rapid and uncertain changes makes information more time-sensitive (Weiss and Heide 1993). This includes even the value of knowing one’s own past usage patterns. Thus, knowing how much you used a current generation product is not much help in determining the need for the next generation product. Further, advances in technology often impose steep (re)learning curves on customers. These influences combine to create uncertainty among customers about their needs, and the value or utility of a product over time.

As such, we can expect them to act in a risk-averse fashion and therefore pay for “insurance” in the form of a subscription price. Strong evidence of this risk-aversion effect comes from field trials of use based pricing for telephone use. Even when their immediate past period calling patterns show they would profit from a usage sensitive plan, customers strongly prefer flat rate, subscription-style plans, especially as more uncertainties are introduced.

P13: Greater uncertainties faced by customers in TI markets make subscription pricing more attractive than usage pricing.

Migration Decisions

Over-lapping product generations are the norm in TI markets. Norton and Bass (1987) document that successive generations typically arrive when the current generation's sales curve is still rising, and may continue to rise for some time.

Both the launch of a new generation and the withdrawal of the old one become equally significant decisions with over-lapping generations, as well as the decision of whether or not to help prior customers migrate from one generation to another. This decision is complex because of the tensions between a firm's desire to provide state-of-the-art technology through a continuing evolution of new product generations, customers' expectations and fears of obsolescence, and the "footprint of the past" from the installed base's commitments to prior generations of the firm's technology. At a core level, the decision rests on the idea that options are more valuable as uncertainty increases.

A Continuum of Migration Options Figure 4 depicts the options for managing over-lapping generations. It orders the alternatives by the degree to which they enlarge the customer's options. At the bottom end, the firm simply withdraws the older generation as soon as the new one is launched. No special assistance is offered to the installed base. The customer's options are very limited. Lack of parts and service for the incumbent installation may force a decision sooner than they would have liked.

At the next level, the firm withdraws the older generation as soon as the new one is launched, but migration assistance is provided to the installed base. For example, they could provide technical help, allow for trade-ins, or provide backward compatibility through product design, patches, or gateways. Notice the customer's options have enlarged. They can continue upgrading and maintaining the old version, and move to the new version at some later point.

Further up the continuum, the firm sells the old and new generations together for a certain period, following which the old generation is withdrawn. This increases customer options even further. Consider a customer with an installed version (say A) older than the latest one on sale (say B). Even after the newest version (say C) is launched, they still have the option from A to B, or to go to C directly. Finally, at the top of the continuum, the firm sells both old and generations as long as the market desires, and also provides migration assistance to the installed base. We

rely extensively on the real option analysis in Grenadier and Weiss (1997) to develop the arguments below.

Expectations of Fast Paced Advance When customers expect rapid advances, albeit small advances, it pays to increase their options. Customers who anticipate a rapid pace of advances tend to wait for price declines and/or bug fixes in newly launched versions. Such stalling is mitigated by providing migration assistance to the installed base. These customers also tend to bypass completely (“leapfrogging”, in Grenadier and Weiss’s terminology) the newly launched version in anticipation of some yet to be launched future version as documented by Weiss (1994). Such behavior is also mitigated by migration assistance. Absent such assistance, firms will find their revenues swinging wildly with detrimental effect on funding developmental activities.

P14: Greater anticipated pace of advancements call for greater customer migration assistance.

Effects of Significant Advances Recall that technological innovations can be evolutionary or revolutionary. When significant technological improvements are anticipated, customers expect sharp breaks with the past, and know smooth upgrades are not possible. Grenadier and Weiss (1997) show that few customers wait to purchase an older generation of the product, which will be made highly obsolete, at a reduced price when they anticipate a significant new version being launched. In short, there is less to be gained by keeping options open. Consequently, it makes sense to move to the bottom end of the migration assistance continuum. This is a fairly counter-intuitive result since we might expect that firms wish to assist their installed bases with the anticipated disruption. Although subsidies are always welcome, the harsh reality is that customers’ existing assets have been destroyed in a Schumpeterian sense.

P15: Anticipation of significant changes call for less migration assistance.

Uncertainty of Future Evolution of Technology When uncertainty of the future evolution of technology is high, a compelling case can be made to increase customer’s migration options. Uncertainties are greatest when a qualitatively different technology is introduced, but its prospects are highly uncertain. For instance, in 1987, ROLM⁴ introduced the Sigma PBX that ran at 8 Khz unlike their previous CBX product line that ran at 12 Khz. Given ROLM’s history of assiduously maintaining backward compatibility, this break with the past was certain to generate high uncertainty among their customers.

Highly uncertain customers resort to various ploys to resolve their uncertainty. One tendency is to bypass the version closest to their installed version to wait for an even newer version to be launched. Another tendency is to wait for the prices of current generation products to decline before purchasing. The lower price acts as an insurance policy. Selling both the old and the new generations for an extended period of time is especially warranted in these circumstances, especially if the older generation can be sold at reduced prices to encourage customers with even older installed versions to migrate to the next step.

P16: Higher uncertainty among customers about technology evolution call for greater migration assistance.

CONCLUSIONS

We began this paper with the argument that TI markets are important and that marketing scholars need to devote more attention to them. Toward that end we outlined a conceptual framework linking scientific know-how, features of a TI market, and a series of previously unaddressed decisions into a nomological network. Our hope is that our nomological network will inspire both theory development and empirical testing. There are some particularly salient matters in this regard.

It is striking that extant theory is heavily concentrated in the game-theoretic modeling tradition, despite the prevalence of mentalistic constructs like expectations that is so central to the area. The paradigmatic base is quite narrow. To illustrate, customers are usually modeled by economists as updating their expectations in a Bayesian fashion, and as assessing strategic interactions via backward induction. However, we know from work in marketing on decision-making that Bayesian updating is a poor representation of the belief updating process, and forward induction rather than backward induction is the mechanism employed in strategic interactions.

That said, perhaps Bayesian updating and backward induction are reasonable as-if assumptions. If so, empirical verification is the key. However, empirical testing lags far behind. More troubling, the available evidence does not provide support for phenomena often taken for granted as part of the conventional wisdom about TI markets. We observed earlier that Liebowitz and Margolis's (1995) examination of the history of the most (in)famous example of network externalities (Beta-VHS) found no supporting evidence. Similarly, leapfrogging is part of the

marketing vocabulary about TI markets, yet we are able to locate only a single empirical study (Weiss, 1994). In short, this is a rich and untapped empirical area.

From a managerial perspective, we think our nomological network raises some serious challenges to practice extrapolated from conventional markets. To see this, let's represent the marketing process as consisting of four broad stages; a) served market definition; b) product development, c) attracting customers, and d) retaining customers. Our propositions dispute the relevance of common heuristics in each of these stages.

At the served market definition stage, we argue for the fundamental importance of the "what to sell" decision. To the best of our knowledge, this is a completely new issue. To us, it is not just a relabeling of the value chain idea or the vertical integration decision. The enormity of Intel's component branding effort, with a budget among the largest in the world, is an illustrative example of the fundamental importance and competitive significance of upstream positions in TI markets. They are not just anonymous suppliers anymore.

At the product development stage, the QFD-inspired idea of optimizing a product for the needs of a segment gave way to a reference platform designed to meet the most demanding customer segment, regardless of their representativeness. This is a major shift.

At the customer attraction stage, we commonly believe that success is accomplished via product differentiation that heightens the uniqueness of one's offering. Modular design challenges this directly by inviting other firms to "drop-in" their components in place of our components.

Finally, with respect to customer retention, the principal focus has been on improving new product launches, and getting to market quickly. Withdrawal decisions about old products are an afterthought. We challenge this emphasis by placing launch and withdrawal decisions on an equal footing on the migration continuum.

To the manager who is skeptical about the empirical robustness of our propositions, we direct attention to the value of the nomological network itself. Specifically, the eight features of TI markets, and the three continua explicating the options for vertical positioning, transfer rights and migration assistance are useful in framing the decision space even if one is unprepared to buy into the propositions themselves. The structure affords one the opportunity to attend to these issues systematically, rather than piece-meal.

Final Comments

It seems appropriate to reflect at a broader level about TI markets. Two questions arise in this regard. First, are the features we commonly identify with TI markets really new? Second, will they be continue to be relevant into the future? To address the first question, we look at two features of a TI market that have currently garnered considerable attention, but put them through a historical lens.

Contemporary markets are so commonly endowed with multiple sources of compatible, interchangeable components that it is worth remembering that the ability to mix and match components have existed since the Civil War. Advances in machining technology in that period was the key to “unpacking” the production of rifles. Rifle components could then be made to sufficiently exacting specifications such that they could be produced separately and then assembled into a functioning firearm. Thus, compatibility became a central concern in many product markets long ago. Reddy (1987) observes that issues of industry standards have been debated in the literature at least since the turn of the century.

Rapid and volatile technological change has often been noted by economic historians studying bygone eras. For example, it characterized marine engineering between the World Wars, and had profound effects on the adoption of incandescent lighting (due to leapfrogging behavior) during the 1880’s (Passer, 1953). Rosenberg (1976) provides several other historical examples of rapid and volatile technological change.

To us, although the existence of these features is not new, they have become, and will continue to increase in their prominence and significance. Why? Know-how is likely to continue to increase at an increasing rate, fueled in part by continued global communication and infrastructure improvements, and the natural self regenerative nature of know-how. Thus, the predictions below are fairly conservative:

- Unit one cost structures will increasingly dominate decision-making, increasing the variety of pricing and rights transfer formats.
- Products will increasingly be decomposed, opening up many new, fine-tuned vertical positioning options.
- The life of product generations will continue to shrink, and migrating customers across product generations will become increasingly important.

Attending to these types of questions and building on an understanding of TI markets promised by this research effort will help to increase the relevance and influence of marketing as a discipline in the future. Certainly, we do not want to be caught behind if indeed observers are right in saying “we are entering a new economic environment - as different as the moon is from the earth..” (Dyson 1994).

1 This is known as a constitutive definition.

2 We do not make a distinction between products and services since we view them both as offering bundles of tangible and intangible attributes. To avoid needless repetition, we use “product” to refer to both products and services.

3 One “odd” feature is that the cost of producing lower-end products are actually higher than the higher end product if the latter was the initial design. To illustrate, an implantable cardiac assist device offered lower end versions that consisted of the exact design as the high end product but with certain features disabled by incurring a small, additional manufacturing cost. It is the relatively small size of these additional costs compared to serving new segments that allows such “deliberate waste” to be nevertheless efficient overall.

4 ROLM: The Sigma Introduction, Harvard Business School Case 9-590-082, Revised January 1997.

Figure 1
Conceptual Framework

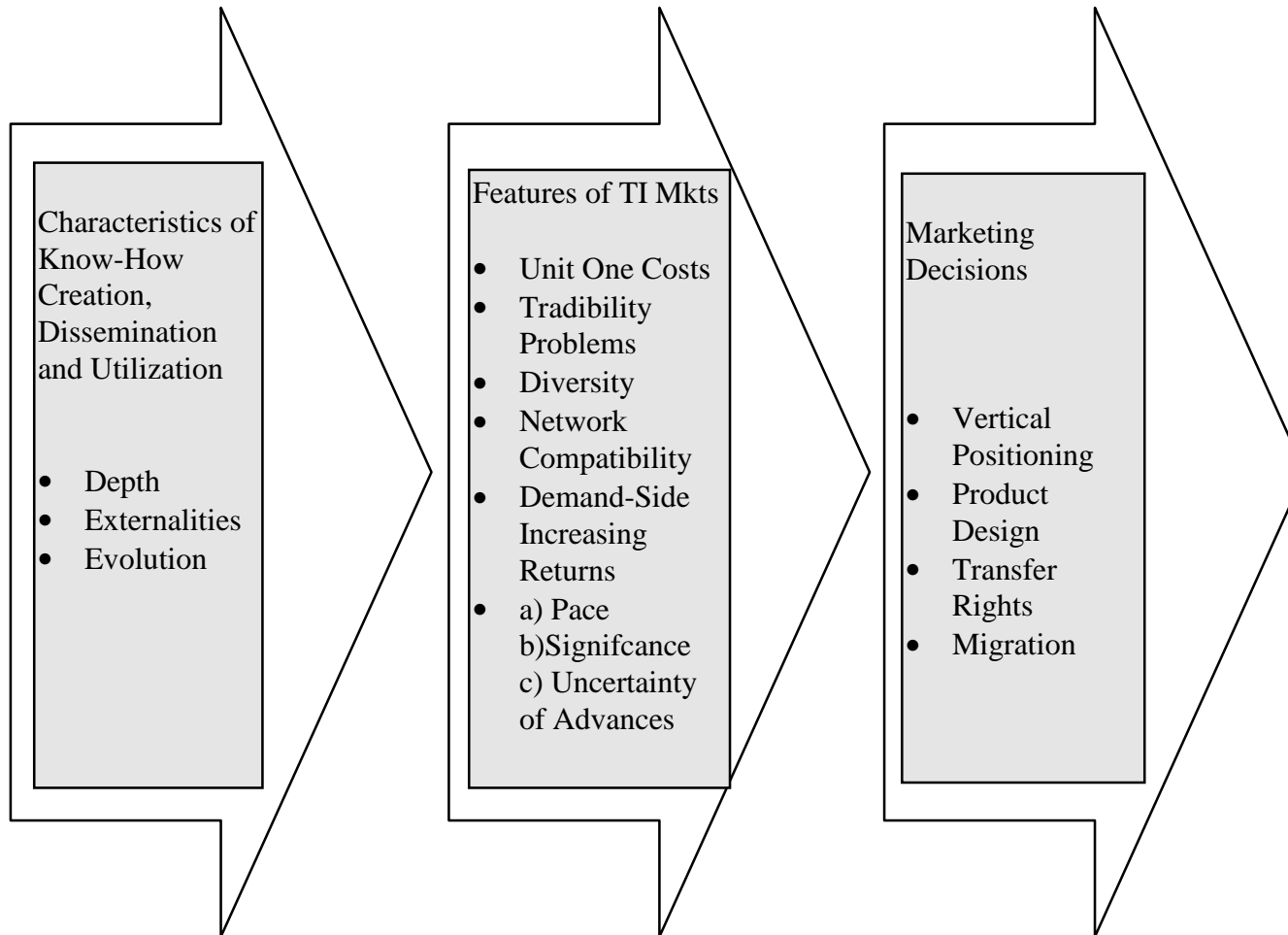


Figure 2
Continuum of Vertical Positions

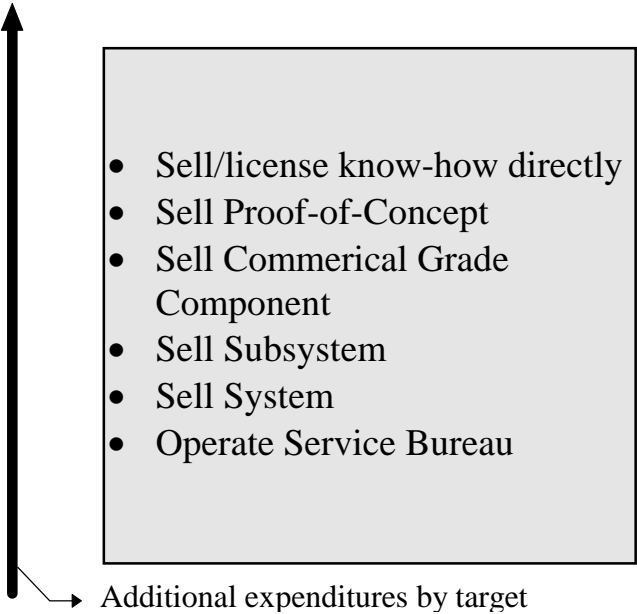


Figure 3
Continuum of Transfer Rights

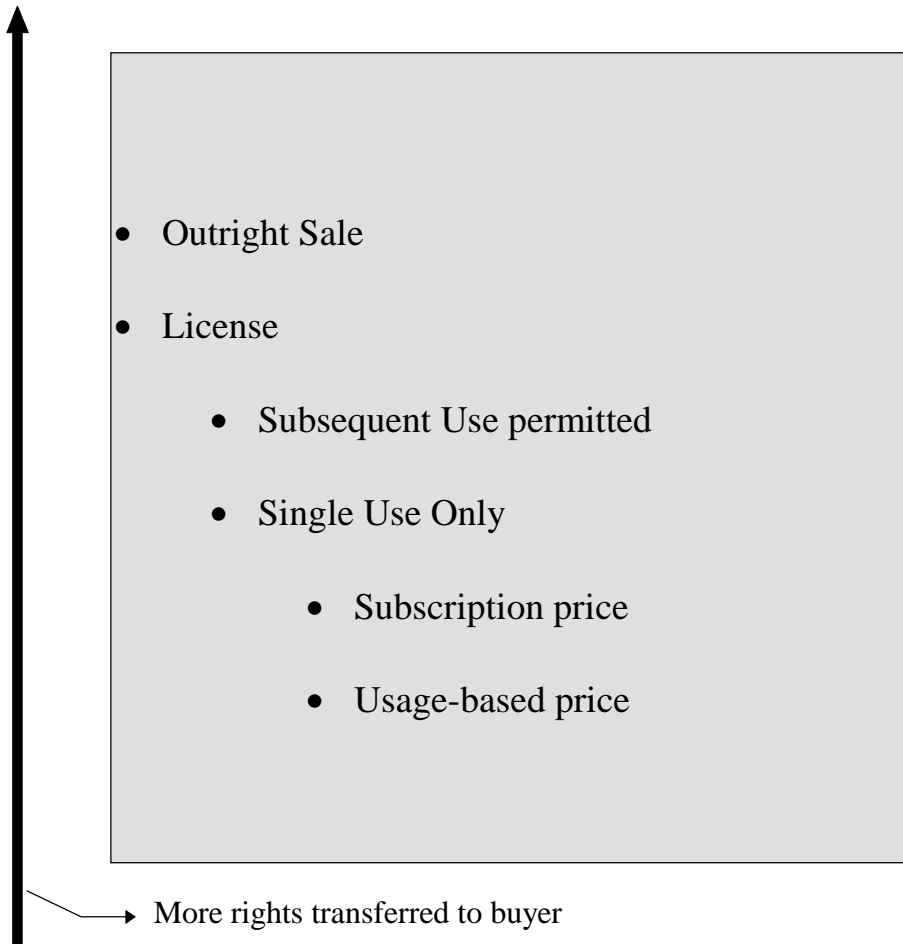
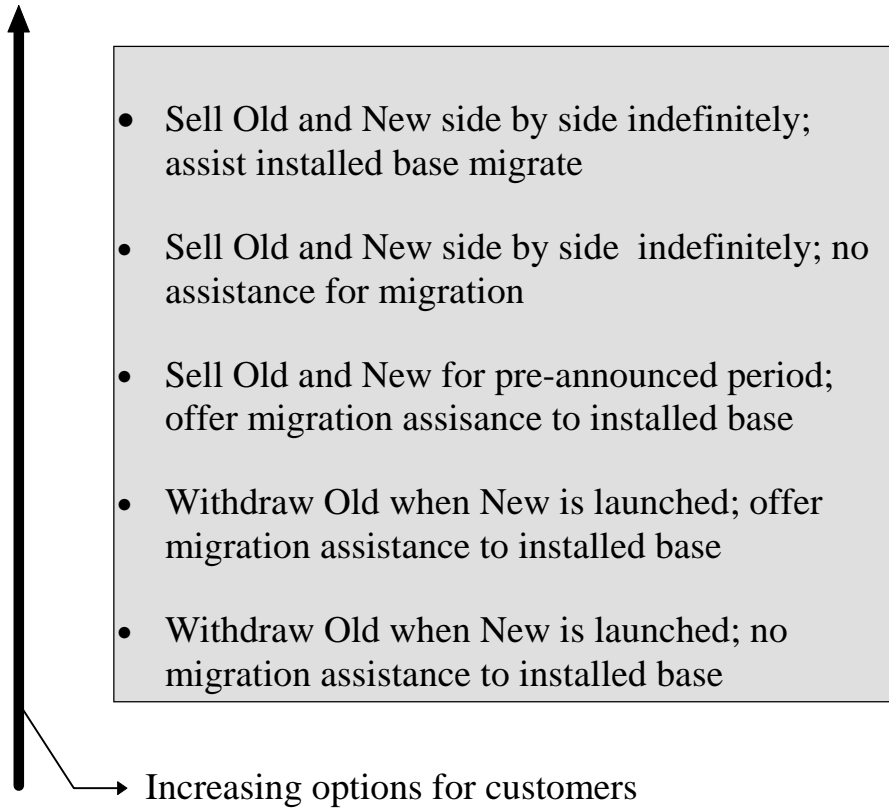


Figure 4
Continuum of Migration Options



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